Institute of Paper Science and Technology
Atlanta, Georgia

OPTIMIZATION OF RECYCLED FIBER IN LINERBOARD

Project 2697-53

Status Report

to

RAC Container and Board Subcommittee

September 25-26, 1979

SUMMARY

This status report summarizes research in progress on ozonation and other chemical treatments to increase the bonding potentials of recycled fiber.

1. When blends of untreated liner/ozonated medium and vice versa were prepared, it appeared that ozonation of the medium fraction was more effective than ozonation of the liner in achieving significant increases in certain properties such as burst and tensile. These increases were achieved at low levels of O_3 consumption based on total fiber weight.
2. Pre-refined OCC responds to ozonation in a manner similar to the unrefined OCC treated in past work. However, the magnitude of the changes in strength depends on the property being considered as well as the level of ozonation and refining.
3. Ozonation work in progress or planned in the following areas is described.
   a. Blends of virgin/ozonated OCC.
   b. Low (1-3%) consistency ozonation.
   c. Process and pilot development.
4. Trials on treatments utilizing green liquor, white liquor, sodium hydroxide, sodium carbonate, and hydrogen peroxide are also summarized. These trials were carried out at elevated temperatures and pressures in an Asplund defibrator. Relative to a control sample processed in the same manner, these treatments produced small to modest improvements in burst and tensile at constant freeness. However, some difficulties were encountered due to losses in "fines" and additional work is required to clarify the effects of treatment and yield loss.

separately ozonated to various levels. The ozonated fraction was then blended with the untreated fraction in a 70% liner, 30% medium ratio prior to handsheet preparation. This ratio approximates the composition of the original OCC composition.

The liner and medium fractions of the Institute "model" OCC were separated by soaking, disintegrated, fluffed, and ozonated in accordance with procedures previously established for the OCC composite. This separation yielded a liner fraction of essentially 100% softwood kraft and a medium fraction of approximately 80% hardwood NSSC and 20% softwood kraft. Single trials at ozonation levels of approximately 0, 2.5, 4.8, and 8.8% ozone consumed based the o.d. liner weight were performed on the liner fraction. These ozonated fractions were blended with untreated medium in a 70% liner, 30% medium ratio. Ozone consumption levels of 0, 1.7, 3.3, and 6.2% based upon the o.d. fiber weight of the final blend resulted.

The medium fractions were ozonated to levels of 0, 4.4, 8.3, and 11.8% ozone consumed based upon o.d. weight. The ozonated medium fractions were then blended with untreated liner at the 70%:30% ratio to provide ozone consumption levels in the final blend of 0, 1.3, 2.5, and 3.5% based on the o.d. fiber weight of the final blend. The higher ozonation levels for the medium were chosen because the medium provides the smaller fraction of the total composite.

Table I shows the strength properties of handsheets from the above blends.

Graphs of freeness, tensile, burst, tear, and modified ring vs. O_3 based upon total o.d. fiber weight are shown in Figures 1-3. The results suggest that ozonation of the medium fraction only is effective in achieving significant increases in certain physical properties, particularly burst and tensile at low levels of O_3 consumption based on total fiber weight. At the 1.3% O_3 consumed level (4.4% O_3 consumed on the medium only), increases of 25+% are noted for both

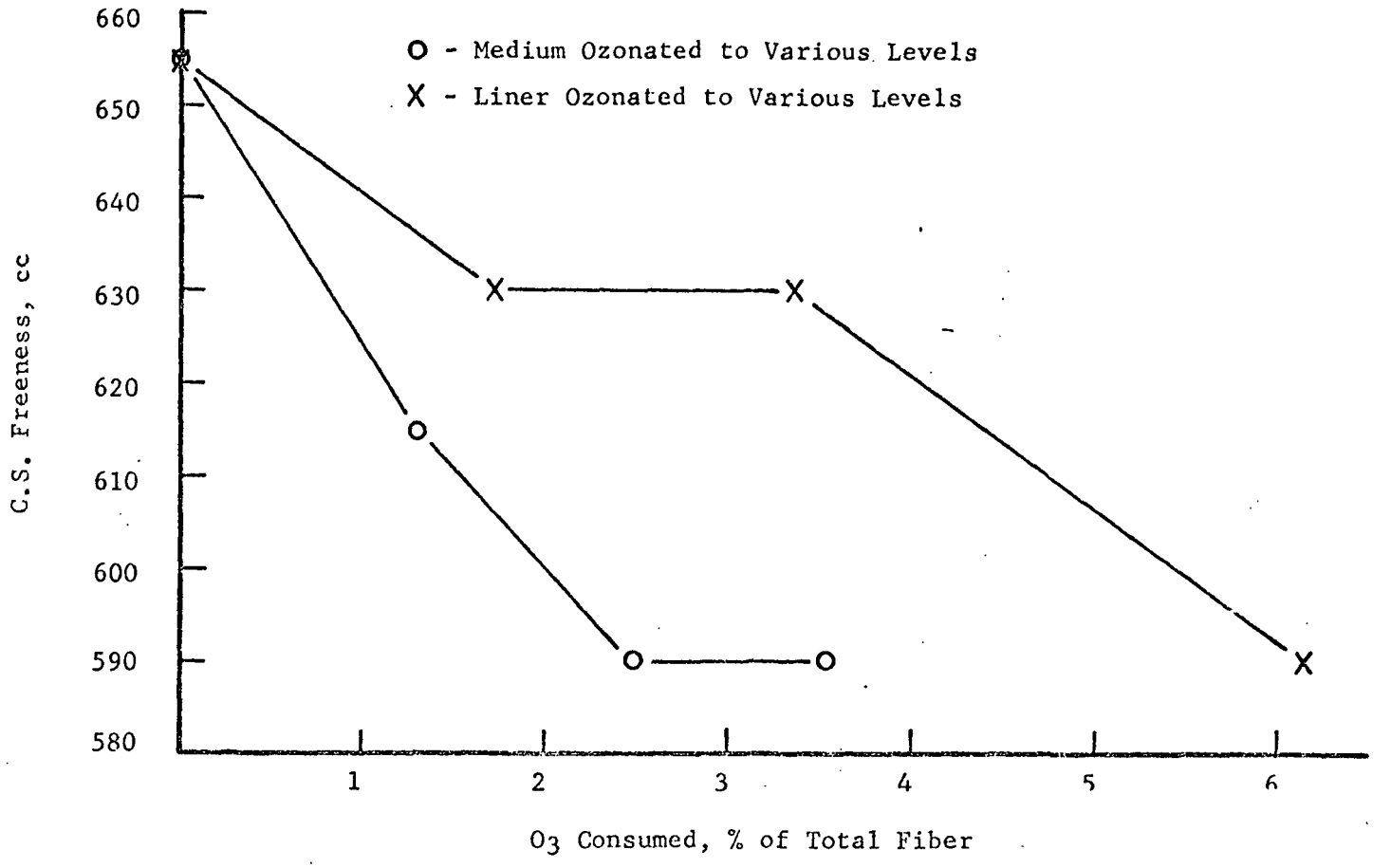
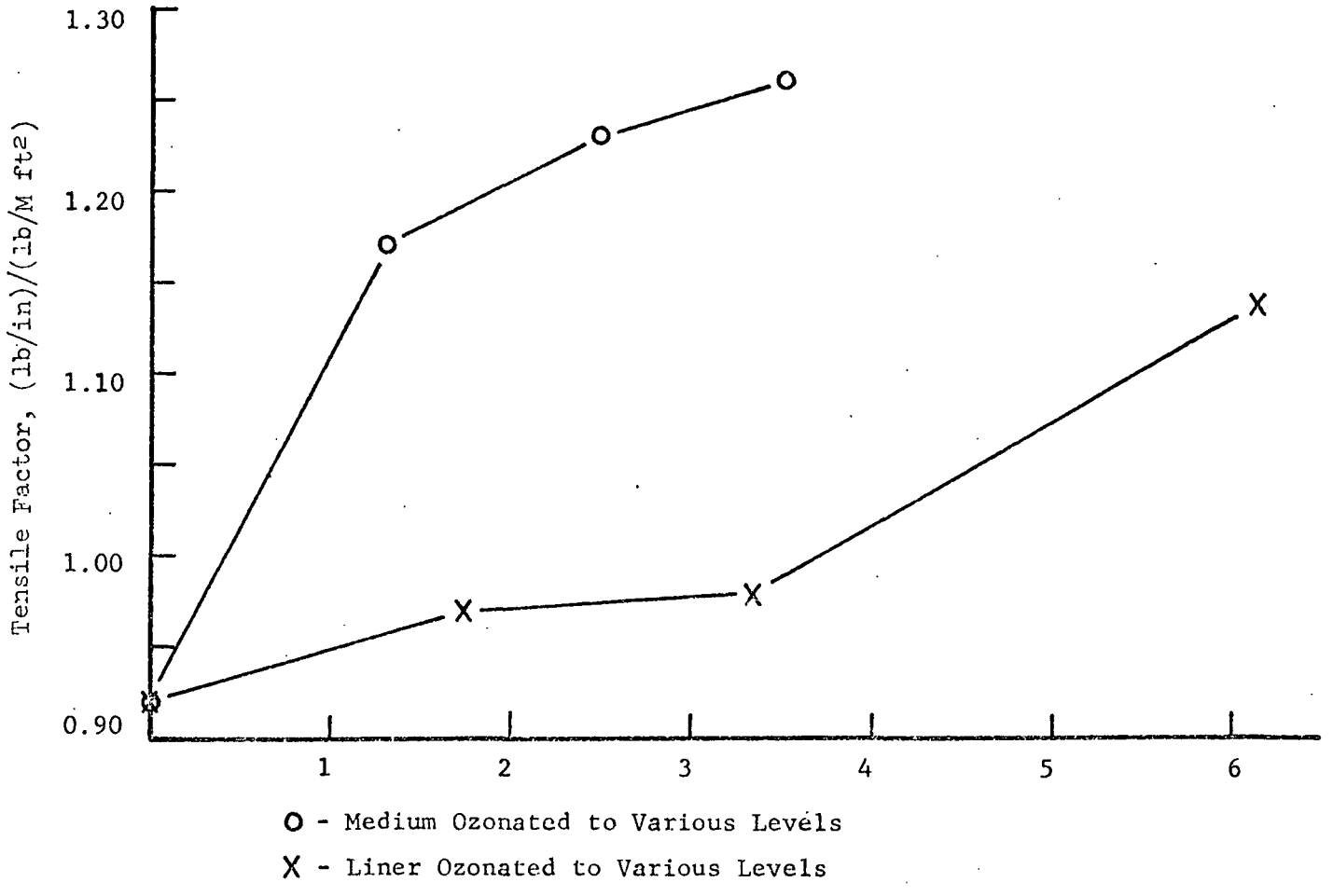


Figure 1. Freeness of Pulps Composed of 70% Liner and 30% Medium.

burst and tensile. This is achieved with a nominal increase in tear as well. Although loss of tear strength has never been serious, increases in other strength properties without a loss of tear strength is desirable. Increases in modified ring were about equal regardless of which fraction of the blend was ozonated.

An important feature of this work relates to previous results which have suggested that ozonation levels of approximately 2.5% O_3 consumed are necessary to achieve significant strength increases in the final paper. The current results suggest that ozonating a fraction of the furnish to a level above the critical 2.5% O_3 level and blending it with the untreated remainder will result in strength



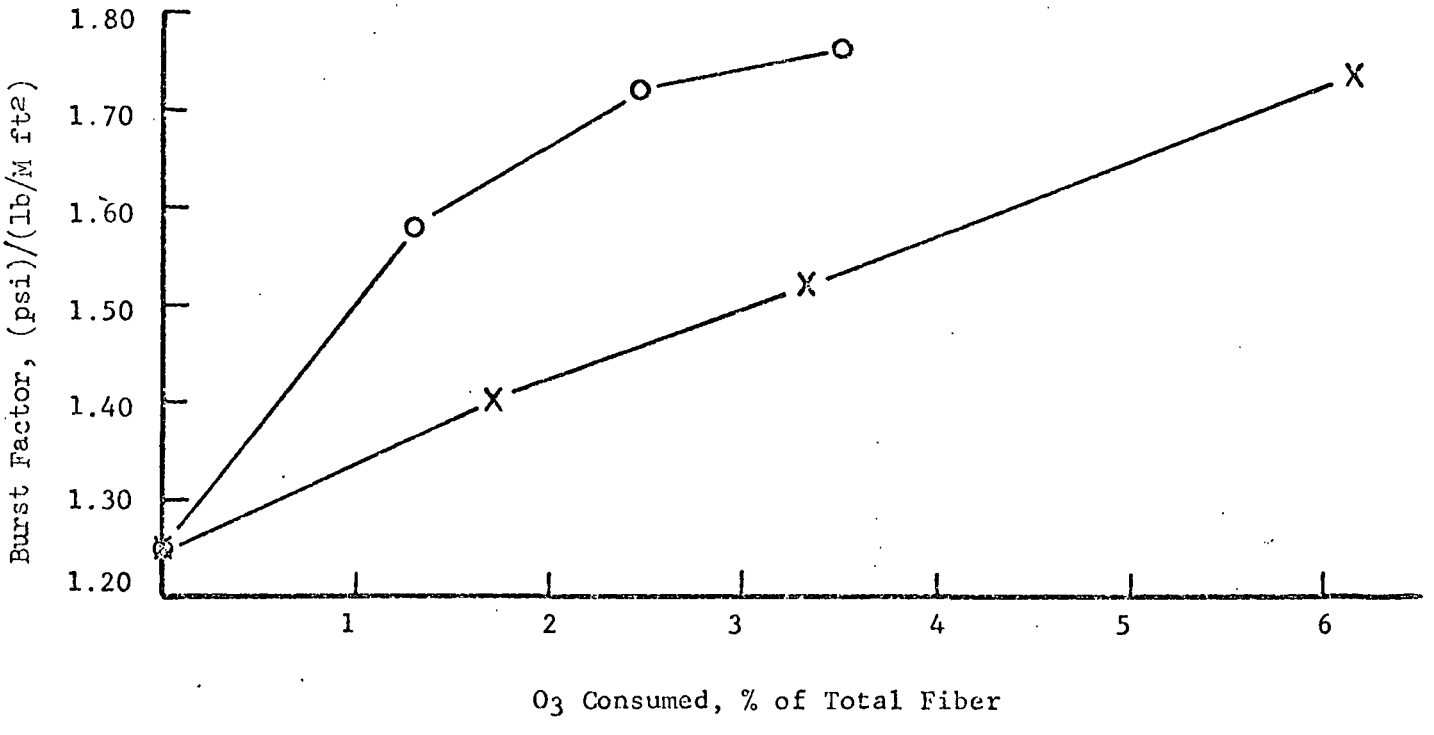


Figure 3. Burst and Tensile Factors of Handsheets Composed of 70% Liner and 30% Medium.

TABLE II

Effect of Pre-refining and Ozonation on Handsheet Properties

C.S. Freeness ml	Ozone Applied %	Ozone Consumed %	Basis Weight lb/M ft²	Caliper mil	Apparent Density (lb/M ft²)/ mil	Burst, psig	Burst Factor (psig)/ (lb/M ft²)	Burst Factor Percent Change[a] Refining	Ozonation	Total
					650 ml Initial Freeness					
650	0.00	----	13.6	5.6	2.41	17.3	1.28	----	----	----
615	2.62	2.56	13.0	5.0	2.62	21.3	1.64	----	+28.1	+ 28.1
610	5.01	4.75	13.7	5.0	2.73	28.3	2.06	----	+60.9	+ 60.9
					595 ml Initial Freeness					
595	0.00	----	13.8	5.1	2.71	26.0	1.88	+46.9	----	+ 46.9
540	2.50	2.44	13.2	4.5	2.90	28.9	2.20	+46.9	+25.0	+ 71.9
505	4.86	4.58	12.9	4.3	3.00	33.1	2.56	+46.9	+53.1	+100.0
					520 ml Initial Freeness					
520	0.00	----	13.2	4.8	2.76	27.8	2.10	+64.1	----	+ 64.1
450	2.62	2.53	13.1	4.4	2.99	32.7	2.50	+64.1	+31.3	+ 95.4
445	5.12	4.86	13.2	4.3	3.04	36.0	2.74	+64.1	+50.0	+114.1
					340 ml Initial Freeness					
340	0.00	----	13.4	4.7	2.86	33.3	2.49	+94.5	----	+ 94.5
295	2.42	2.34	13.4	4.3	3.11	38.9	2.91	+94.5	+32.8	+127.3
275	4.82	4.54	13.3	4.2	3.18	39.3	2.96	+94.5	+36.8	+131.3

[a]Percent differences based on untreated OCC at 650 ml freeness

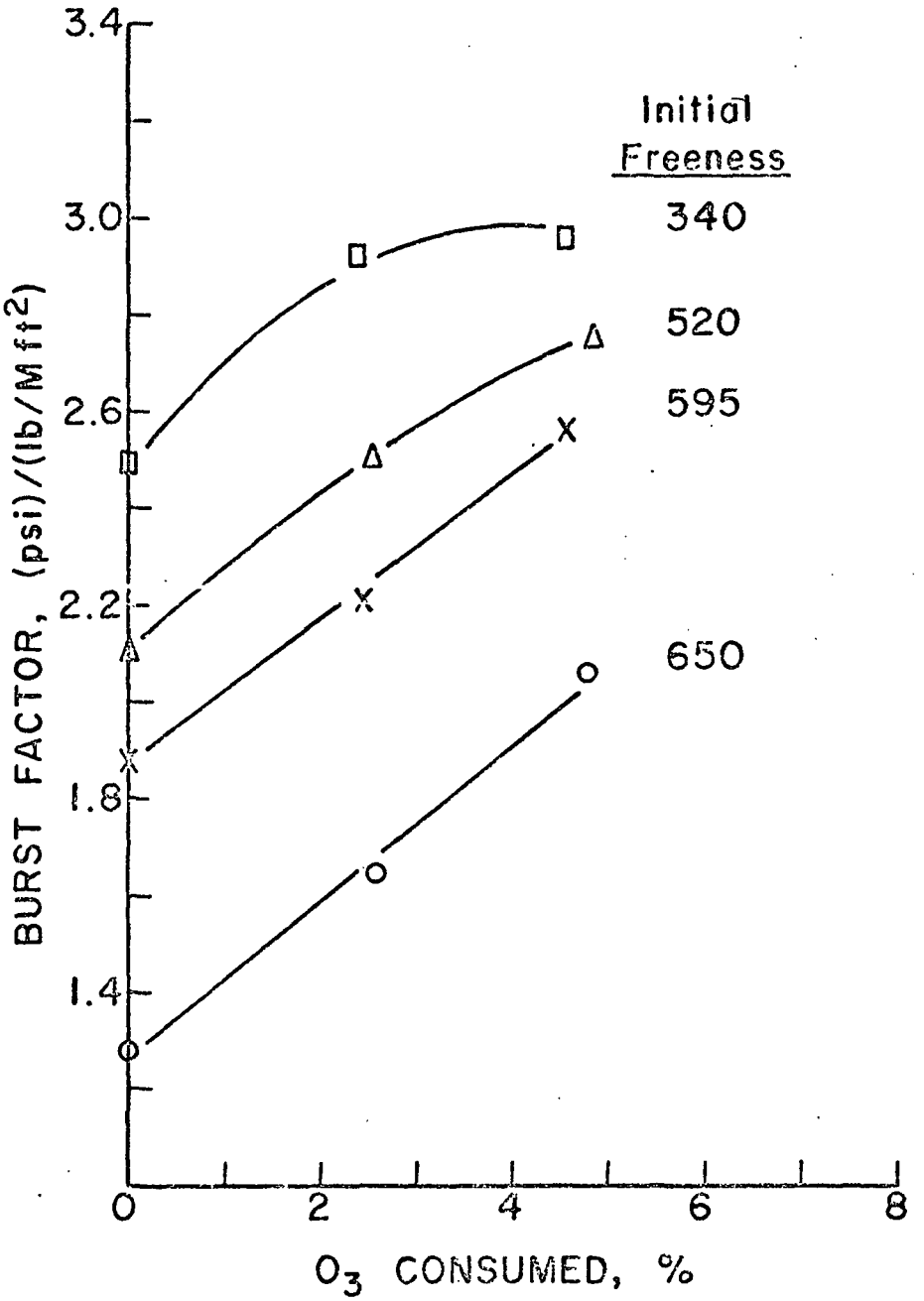


Fig 4 EFFECT OF PRE-REFINING AND OZONATION ON BURST FACTOR

generally exhibit higher freeness than the untreated control. Thus, ozonation after pre-refining appears to increase bursting strength a greater amount than would be expected on the basis of mechanical refining alone.

The modified ring compression results in Figure 6 show that ozonation after pre-refining effected modest increases in strength as has been obtained in previous work. When the ring results are plotted vs. freeness, it appears that the ozonated sheets exhibit about the same strength levels as the untreated refined control down to about 450-500 ml C.S. freeness (See Figure 7). At lower freenesses, the ozonated sheets tended to exhibit higher ring compression strengths than the refined control.

Figure 8 shows that ozonation substantially increased the Concora strength of the pre-refined sheets, particularly on the stocks which were pre-refined to 595 and 650 ml freeness. The increases in Concora strength were approximately proportional to the level of ozonation as in the case of bursting strength. Figure 9 shows the Concora results graphed vs. freeness. At equal freeness, the 4.9% ozonated sheets generally exhibit higher Concora strengths than the mechanically refined control. At the 2.5% O_3 level, the Concora strengths were about the same as obtained on the untreated refined control. Thus, as the degree of ozonation increases, the Concora strength at a given freeness is greater than achieved with mechanical refining.

The results in Figure 10 show that ozonation generally increased tensile strength above that of the pre-refined controls depending on the ozonation level. However, the changes in tensile strength were relatively small at the 2.5% O_3 for the stocks pre-refined to 520 and 595 ml.

With regard to other properties, ozonation generally effected large changes in tensile energy adsorption (TEA) at all levels of pre-refining. The effects of ozonation on tearing strength were generally small at all levels of pre-refining.

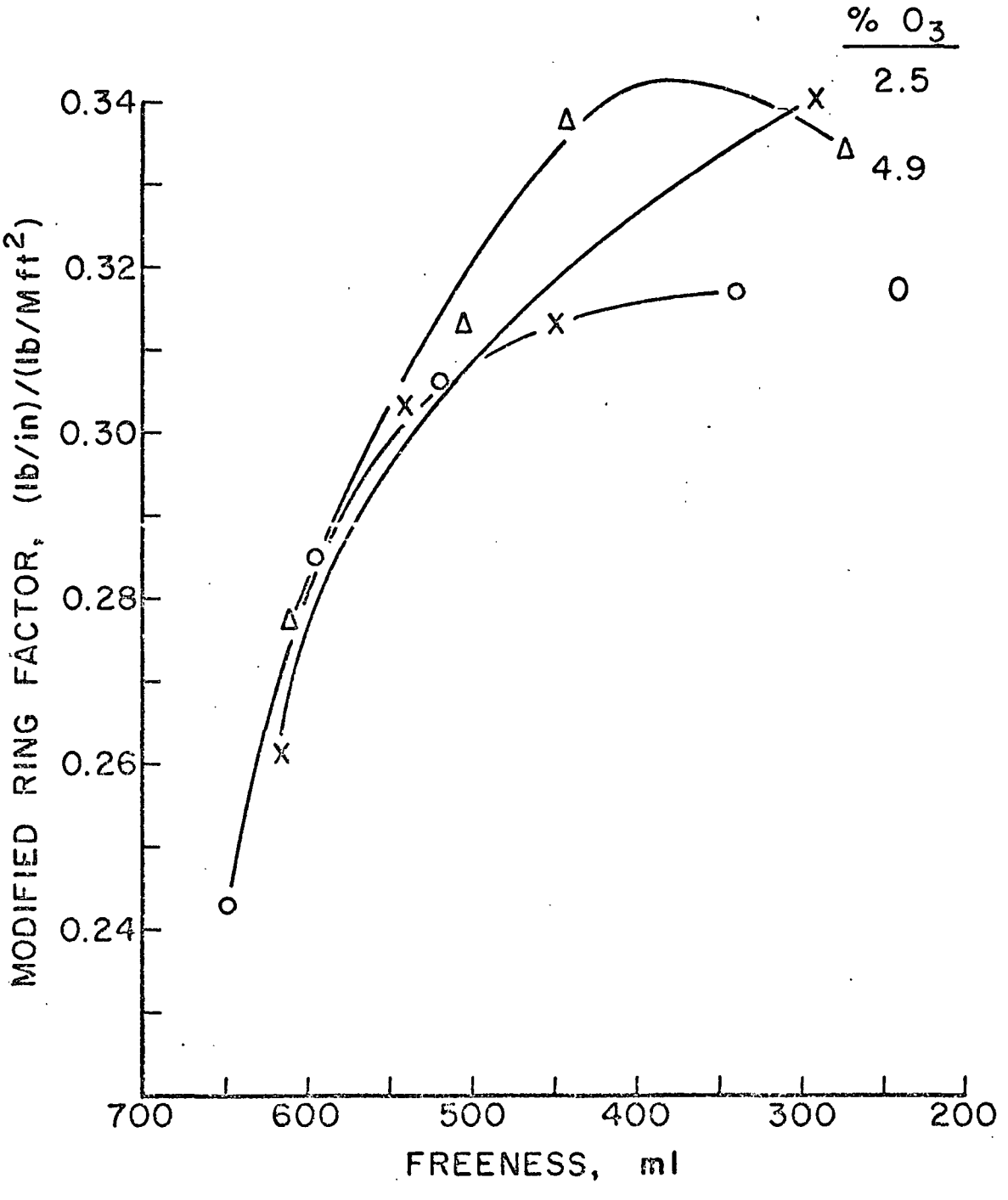


Fig 7 MODIFIED RING COMPRESSION FACTOR vs FREENESS AT VARIOUS PRE-REFINING AND OZONATION LEVELS

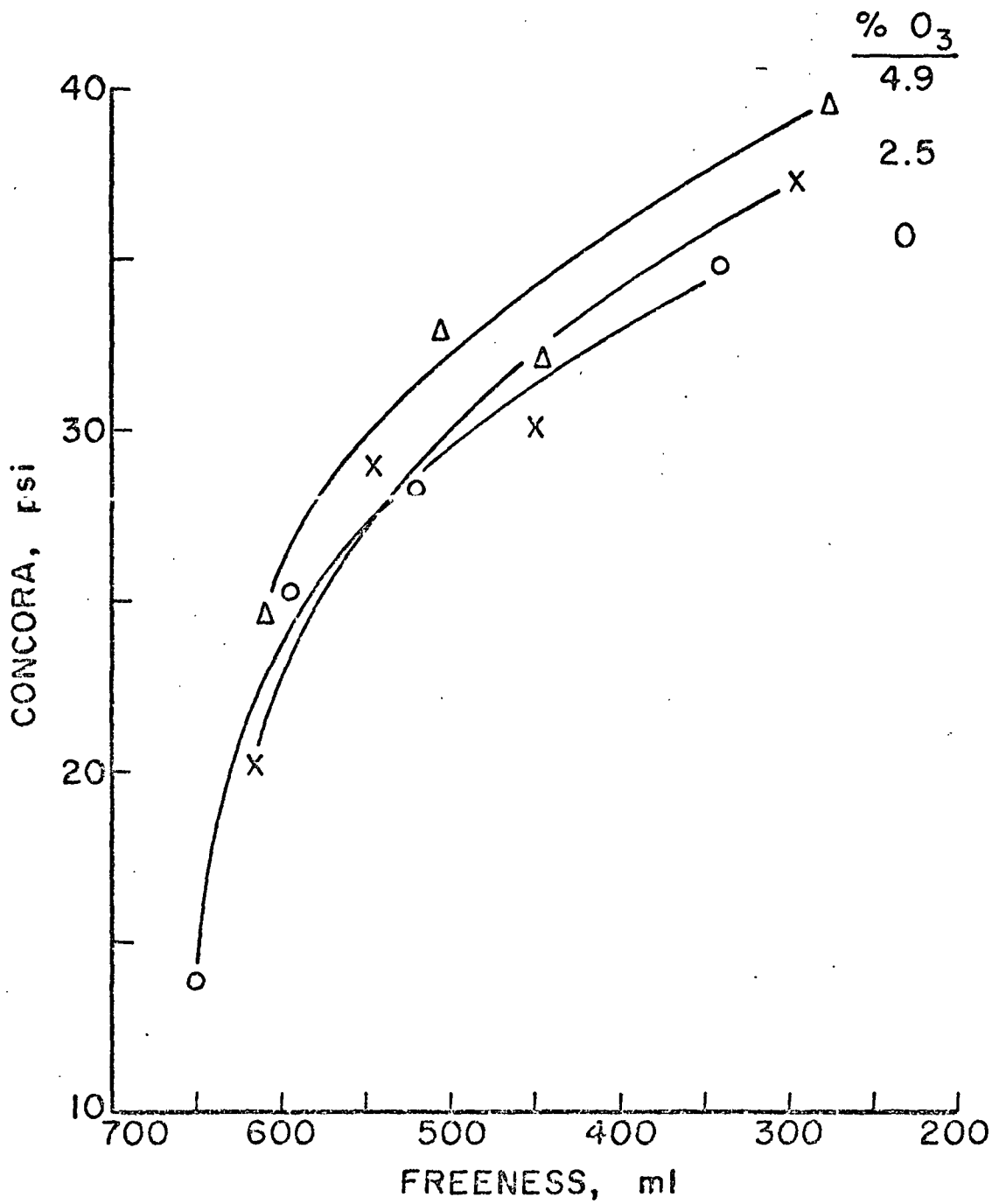


Fig 9 CONCORA STRENGTH vs FREENESS AT VARIOUS PRE-REFINING AND OZONATION LEVELS

Briefly summarizing, it appears that pre-refined OCC responds to ozonation in a manner similar to the unrefined OCC treated in past work. However, at a given level of refining, the magnitude of the changes in strength depends on the property being considered as well as the level of ozonation.
Further work is planned to evaluate the effects of post-refining on ozone treated OCC; however, it is being rescheduled to a later time in order to speed up present work on blends of virgin/ozonated stocks.

Blends of Virgin Kraft and Ozonated OCC

There are a number of ways in which the untreated and ozonated fiber components of linerboard may be combined. For example, several alternatives are noted below.

1. Ozonated OCC combined with untreated virgin primary stock.
2. Ozonated long fiber fraction combined with untreated virgin and short fiber fraction.
3. Ozonated short fiber fraction combined with untreated virgin and long fiber fraction.
4. Ozonated virgin kraft combined with untreated OCC.

Another variable which will affect performance of the various furnish combinations is the degree and type of refining. Considerable experimentation will be required to determine the most appropriate way to ozonate, refine, and combine the various fiber components. The variables to be considered include:

1. Ozonation level.
2. Virgin/OCC blend ratio.
3. Degree of pre- or post-refining.

Research is in progress in this area. The first study involves evaluation of blends of ozonated OCC with virgin in a ratio of 60:40. Two levels of ozonation

inasmuch as marked increases in brightness of ozonated pulps were obtained. However, it was not possible to treat enough stock to carry out strength tests.

Design and construction of a suitable apparatus will require considerable process design time and expense. Therefore, we are in the process of determining if Lindholm or his co-workers would be interested in carrying out low consistency trials on our OCC stock. This would expedite evaluation of the possible advantages of the low consistency process.

Process and Pilot Development

The present laboratory ozonation equipment and process are far removed from possible pilot and commercial processing. The critical areas are the reactor and, to a lesser extent, the proper fluffing/dewatering of the stock. Because of these limitations, we are considering ways to carry out pilot scale operations which would permit us to obtain better estimates of the operating and capital costs of the process as well as to demonstrate the technical feasibility of the process on a larger scale.

Accordingly, we have contacted two organizations with experience and/or pilot plant facilities in the pulp ozonation treatment area. They are:

1. Pulp and Paper Research Institute of Canada.
2. Improved Machinery, Inc., (Impco) subsidiary of Ingersoll-Rand, Nashua, New Hampshire.

Impco's letter response to our initial inquiry is appended to this report. The following is quoted from their letter.

1. "Impco is most anxious to work with the Institute and through the Institute with members of the consortium sponsoring this work. Once the practicality of the system and process is proven, it has been Impco's past policy to share in the development of a commercial scale installation. Much needs to be learned before we reach this point."

Elevated Temperature and Pressure Treatments

The following treatments have been carried out in the Asplund defibrator to simulate the effect of chemical treatments in A/D systems. The processing has been carried out using 135 grams o.d. fiber with the selected amount of chemical. The consistency of the stock was about 25-30% and the following chemical levels have been used.

1. Caustic soda (NaOH): 3 and 5% o.d. fiber; 5 minute dwell time using 100 psi steam.
2. Sodium carbonate: 8 and 13.25%; same Asplund conditions as caustic soda.
3. Hydrogen peroxide (2%) in an alkaline slurry; same Asplund conditions as caustic soda.
4. "Green" liquor: 3 and 5% on o.d. fiber; 2.5 minute dwell time using 50 psi steam (concentrations based on equivalent Na_2O).
5. "White" liquor: 3 and 5% on o.d. fiber; same conditions as "Green" liquor.

The trials on "green" and "white" liquor were added at the recommendation of the FKBG Reclaimed Fiber subcommittee. They suggested that the Asplund conditions should involve about a 2 1/2 minute dwell time using 50 psi steam rather than the 5 minute dwell time at 100 psi which was employed for the other agents. Because of the differences in processing conditions, the "green" and "white" liquor treatment trials are separately discussed herein.

Post-Treatment Processing Considerations

After treatment in the Asplund with the selected chemical, the stocks were washed on a Valley flat screen and collected on a muslin-covered wash box in the usual manner. Asplund control runs were also carried out at each Asplund

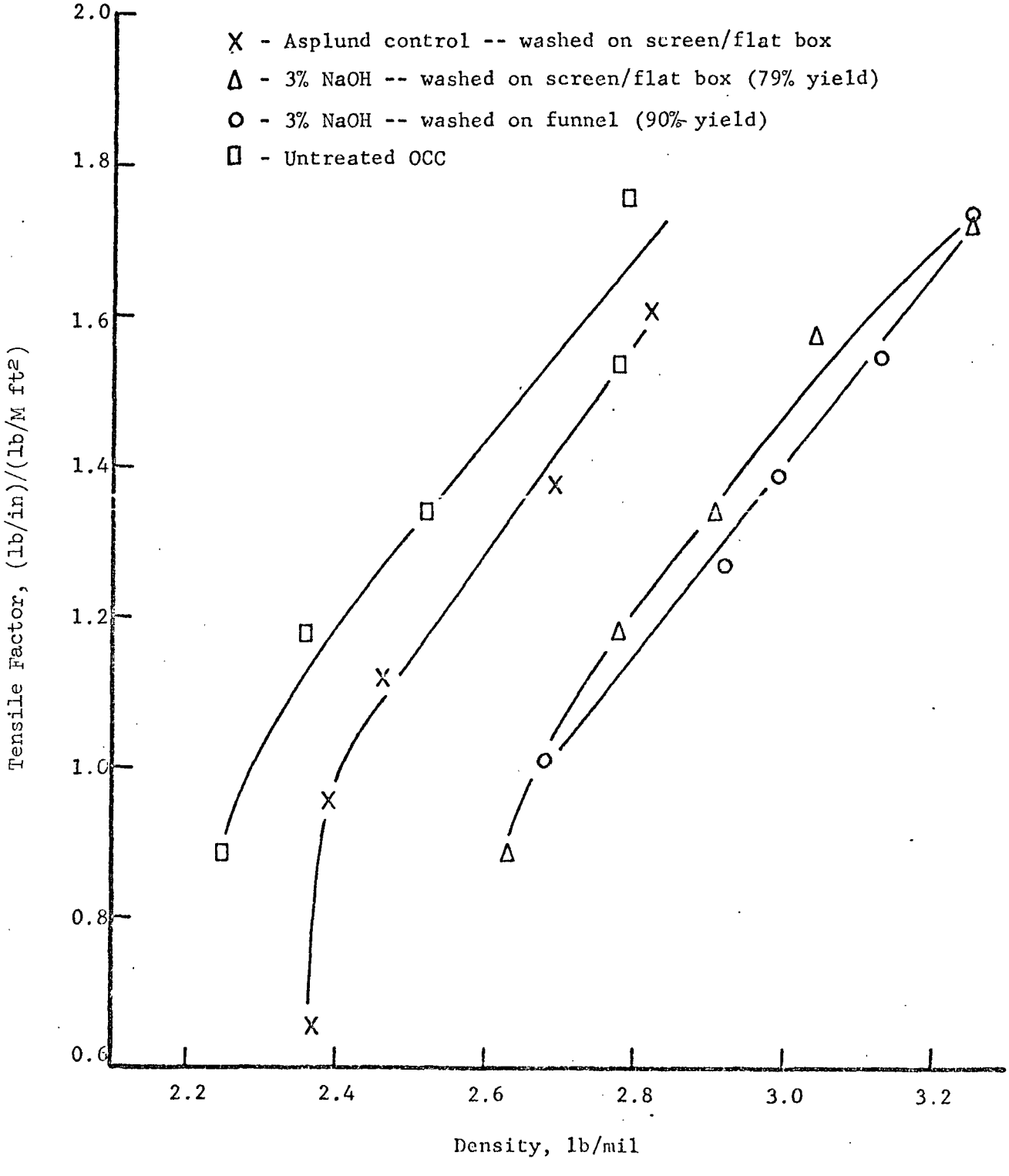


Figure 11. Effect of Washing Technique on Tensile vs. Density Relationship.

Figure 13 shows that the burst factor vs. density relationships were similar to the tensile strength results. Thus, the caustic treated stocks exhibited essentially the same relationship to density for both washing techniques. At a given density, the Asplund control and the untreated OCC exhibited about the same burst strength and both were higher than the caustic treated stocks.

The burst results in Figure 14 indicate that the caustic treated stock at 90% yield exhibited lower strength at a given freeness than the lower yield stock. Conversely, at a given burst level, the higher yield caustic treated stock had a considerably lower freeness than the caustic treated stock which had lost "fines" in the washing. At a constant freeness, the caustic treated stock which was washed on the screen exhibited higher strengths than the Asplund control which was washed in a similar manner.

Figure 15 shows that the ring compression factors obtained in the caustic treated stocks tended to be lower than obtained on the Asplund control and untreated OCC except at the initial beating intervals. The main effect of the difference in washing technique on the caustic treated results was to shift the response to higher freeness.

In general, these results indicate that the Asplund control which was processed in the same manner as in the case of the chemical treatments is the most appropriate reference to assess the effect of the treatments evaluated in these studies. However, the strength responses all shifted to higher freeness levels which is attributed to the loss of some "fines" in the washing process. It is an interesting and perhaps significant observation that the loss of a small percentage of "fines" tends to markedly increase most properties except ring compression at a given freeness. If the "fines" loss is minimized, much lower freeness is obtained which would lower productivity.

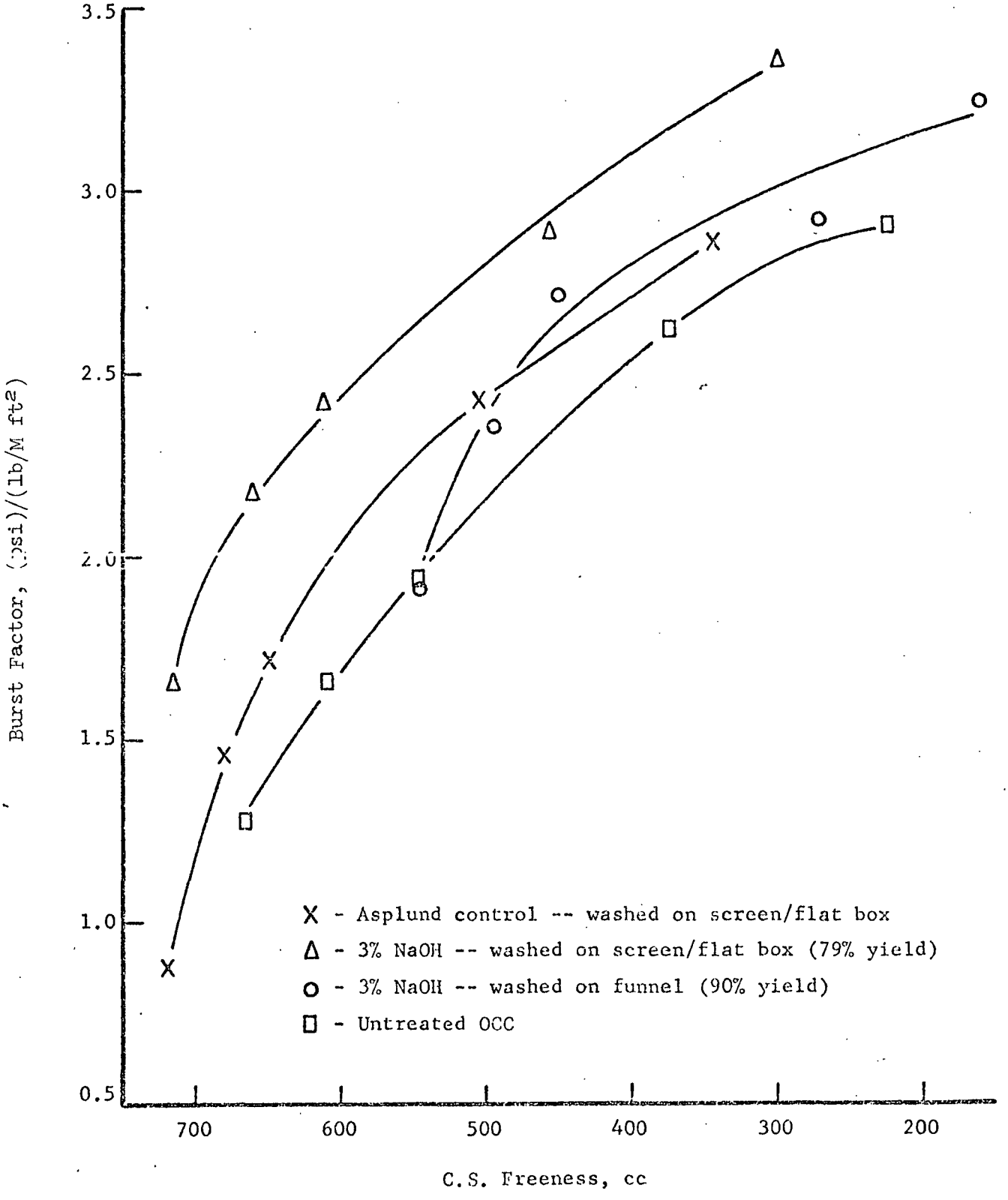


Figure 14. Burst vs. Freeness Relationships.

"Green" and "White" Liquor Treatments

For these trials, synthetic liquors were prepared having the following chemical amounts per 500 ml water.

	"White" Liquor	"Green" Liquor
Sodium Hydroxide	46.9g	----
Sodium Carbonate	15.0g	77.1g
Sodium Sulfide	15.7g	15.7g

The above liquors were added to the OCC stock to give concentrations of 3 and 5% based on o.d. fiber.

The chemically treated stock was placed in the prechamber of the Asplund and heated with 50 psi steam for 2 1/2 minutes. The pulp was then blown in to the defibrator chamber and fiberized for about 75 seconds. Tap water (1.5 l) was then blown into the defibrator from the prechamber using 150 psi steam and the pulp was then blown from the chamber into a cyclone separator using 100 psi steam. Tap water was again introduced into the defibrator chamber, the defibrator motor was restarted, and the water was blown into the cyclone. The several charges required for each treatment condition were mixed, washed on a Valley flat screen, and collected on a muslin-covered wash box. The so-treated stocks were dewatered in a centrifuge to about 33% consistency and stored in a cold room before making beater runs.

The beater curve results on the "white" and "green" liquor treated stocks are tabulated in Tables III and IV, respectively.

The Asplund control results are identified as the 50 psi steam, 0% chemical trial in the tables. The Asplund control runs received the same processing as the chemically treated stocks. The untreated OCC results from the March, 1979, status report are also shown in the tables and are identified at atmospheric pressure, 0% chemical trials. As discussed previously, this untreated stock was merely dispersed and dewatered prior to beating.

TABLE III Continued

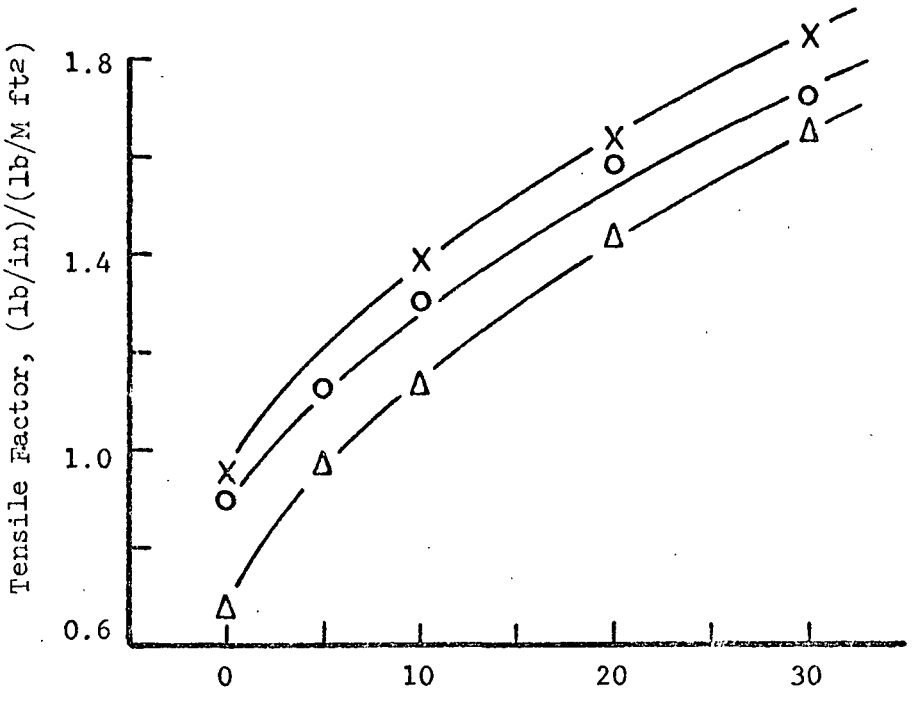
Treatment Pressure psi	Treatment % "White" Liquor	C.S. Freeness	Mod. Ring Factor lb/in / lb	Diff. %[d]	Et Factor lb/in / lb	Diff. %[c]	TEA ft/lb / ft^2	Diff. %[d]	Stretch %	Diff. %[d]	Concora psi	Diff. %[d]
					0 Minute Beating Time							
Atm.[a]	0	665	0.304	+94.9	126.3	+19.6	1.8	+12.5	1.73	- 6.0	---	---
50[bc]	0	730	0.156	---	105.6	---	1.6	---	1.84	---	9.5	---
50[c]	3	725	0.192	+23.1	126.9	+20.2	3.0	+87.5	2.52	+37.0	19.0	+100.0
50[c]	5	720	0.229	+46.8	123.2	+16.7	2.9	+81.2	2.59	+40.8	18.5	+ 94.7
					5 Minute Beating Time							
Atm.[a]	0	605	0.331	+54.0	148.2	---	2.8	+ 3.7	2.09	- 5.4	---	---
50[bc]	0	700	0.215	---	131.8	---	2.7	---	2.21	---	14.8	---
50[c]	3	690	0.238	+10.7	146.7	+11.3	3.6	+33.3	2.55	+15.4	25.2	+ 70.2
50[c]	5	665	0.253	+17.7	142.8	+ 8.3	3.9	+44.4	2.73	+23.5	25.9	+ 75.0
					10 Minute Beating Time							
Atm.[a]	0	545	0.377	+46.1	152.1	+15.3	3.5	+ 9.4	2.14	- 7.4	---	---
50[bc]	0	670	0.258	---	131.9	---	3.2	---	2.31	---	20.8	---
50[c]	3	630	0.270	+ 4.6	153.2	+16.1	4.3	+34.4	2.67	+15.6	30.2	+ 45.2
50[c]	5	610	0.262	+ 1.6	154.9	+17.4	4.2	+31.2	2.71	+17.3	29.8	+ 43.3
					20 Minute Beating Time							
Atm.[a]	0	375	0.393	+47.2	163.5	+ 4.7	4.6	+ 7.0	2.51	- 0.4	---	---
50[bc]	0	550	0.267	---	156.2	---	4.3	---	2.52	---	29.5	---
50[c]	3	430	0.273	+ 2.2	176.6	+13.1	5.1	+18.6	2.71	+ 7.5	37.2	+ 26.1
50[c]	5	435	0.296	+10.9	175.8	+12.5	5.5	+27.9	2.82	+11.9	40.2	+ 36.3
					30 Minute Beating Time							
Atm.[a]	0	225	0.415	+31.7	182.8	+ 3.9	4.9	- 3.9	2.56	- 1.2	---	---
50[bc]	0	405	0.315	---	176.0	---	5.1	---	2.59	---	35.4	---
50[c]	3	280	0.291	- 7.6	192.7	+ 9.5	5.7	+11.8	2.75	+ 6.2	40.1	+ 13.3
50[c]	5	255	0.260	-17.5	190.6	+ 8.3	6.0	+17.6	2.86	+10.4	40.1	+ 13.3

Notes: a - Untreated repulped OCC
b - Asplund control (untreated)
c - Estimated solubles losses were about 6-10% and about 10% in fines
d - Differences based on Asplund control as reference

TABLE IV Continued

Treatment Pressure psi	Treatment % "Green" Liquor	C.S. Freeness	Mod. Ring Factor lb/in lb	Mod. Ring Factor Diff. %[d]	Et Factor lb/in lb	Et Factor Diff. %	TEA ft/lb ft^2	TEA Diff. %[d]	Stretch %	Stretch Diff. %[d]	Concora psi	Concora Diff. %[d]
					0 Minute Beating Time							
Atm.[a]	0	665	0.304	+94.9	126.3	+19.6	1.8	+12.5	1.73	- 6.0	---	---
50[bc]	0	730	0.156	---	105.6	---	1.6	---	1.84	---	9.5	---
50[c]	3	730	0.225	+44.2	120.1	+13.7	2.7	+68.8	2.43	+32.1	15.3	+61.1
50[c]	5	720	0.285	+82.7	105.1	- 0.5	2.5	+56.2	2.30	+25.0	15.8	+66.3
					5 Minute Beating Time							
Atm.[a]	0	605	0.331	+54.0	148.2	+12.4	2.8	+ 3.7	2.09	- 5.4	---	---
50[bc]	0	700	0.215	---	131.8	---	2.7	---	2.21	---	14.8	---
50[c]	3	690	0.245	+14.0	142.3	+ 8.0	3.5	+29.6	2.52	+14.0	20.9	+41.2
50[c]	5	690	0.267	+24.2	120.4	- 8.6	3.4	+31.2	2.50	+13.1	22.3	+50.7
					10 Minute Beating Time							
Atm.[a]	0	545	0.377	+46.1	152.1	+15.3	3.5	+ 9.4	2.14	- 7.4	---	---
50[bc]	0	670	0.258	---	131.9	---	3.2	---	2.31	---	20.8	---
50[c]	3	650	0.274	+ 6.2	149.8	+13.6	3.9	+21.9	2.49	+ 7.8	26.9	+29.3
50[c]	5	640	0.287	+11.2	150.3	+13.9	4.2	+31.2	2.56	+10.8	27.9	+34.1
					20 Minute Beating Time							
Atm.[a]	0	375	0.393	+47.2	163.5	+ 4.7	4.6	+ 7.0	2.51	- 0.4	---	---
50[bc]	0	550	0.267	---	156.2	---	4.3	---	2.52	---	29.5	---
50[c]	3	510	0.292	+ 9.4	171.1	+ 9.5	5.1	+18.6	2.64	+ 4.8	34.7	+17.6
50[c]	5	510	0.301	+12.7	165.5	+ 6.0	5.1	+18.6	2.68	+ 6.3	34.8	+18.0
					30 Minute Beating Time							
Atm.[a]	0	225	0.415	+31.7	182.8	+ 3.9	4.9	- 3.9	2.56	- 1.2	---	---
50[bc]	0	405	0.315	---	176.0	---	5.1	---	2.59	---	35.4	---
50[c]	3	360	0.309	- 1.9	183.8	+ 4.4	5.5	+ 7.8	2.72	+ 5.0	38.3	+ 8.2
50[c]	5	340	0.322	+ 2.2	175.0	- 0.6	5.8	+13.7	2.90	+12.0	37.6	+ 6.2

Notes: a - Untreated repulped OCC
b - Asplund control (untreated)
c - Estimated solubles losses were about 6-10% and about 10% in fines
d - Differences based on Asplund control as reference



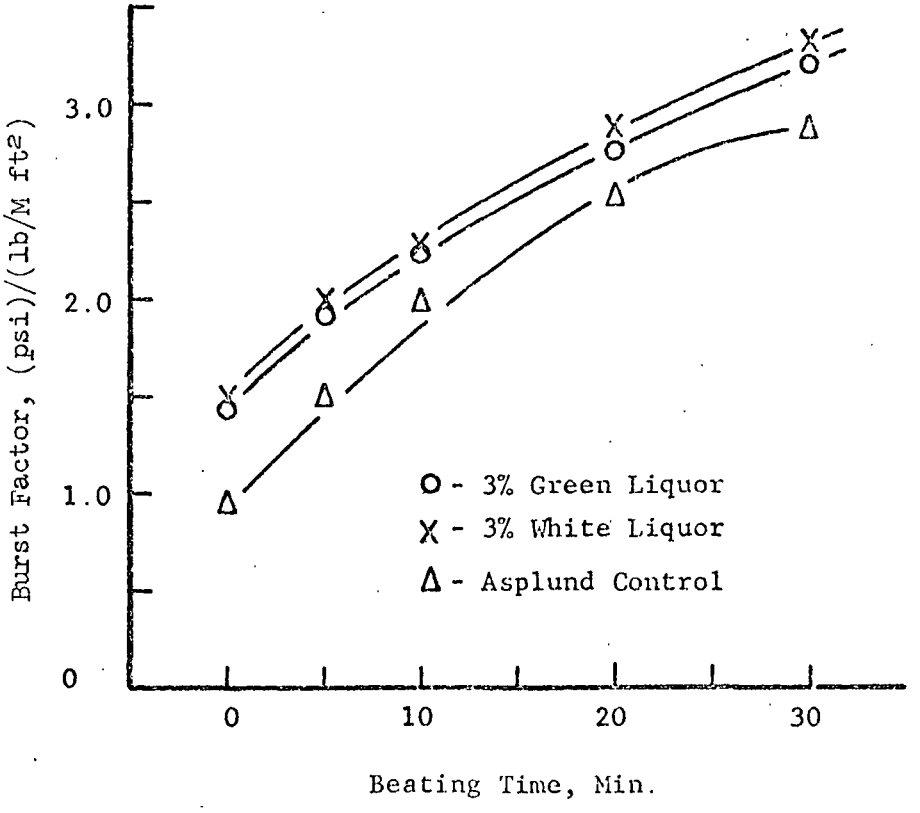
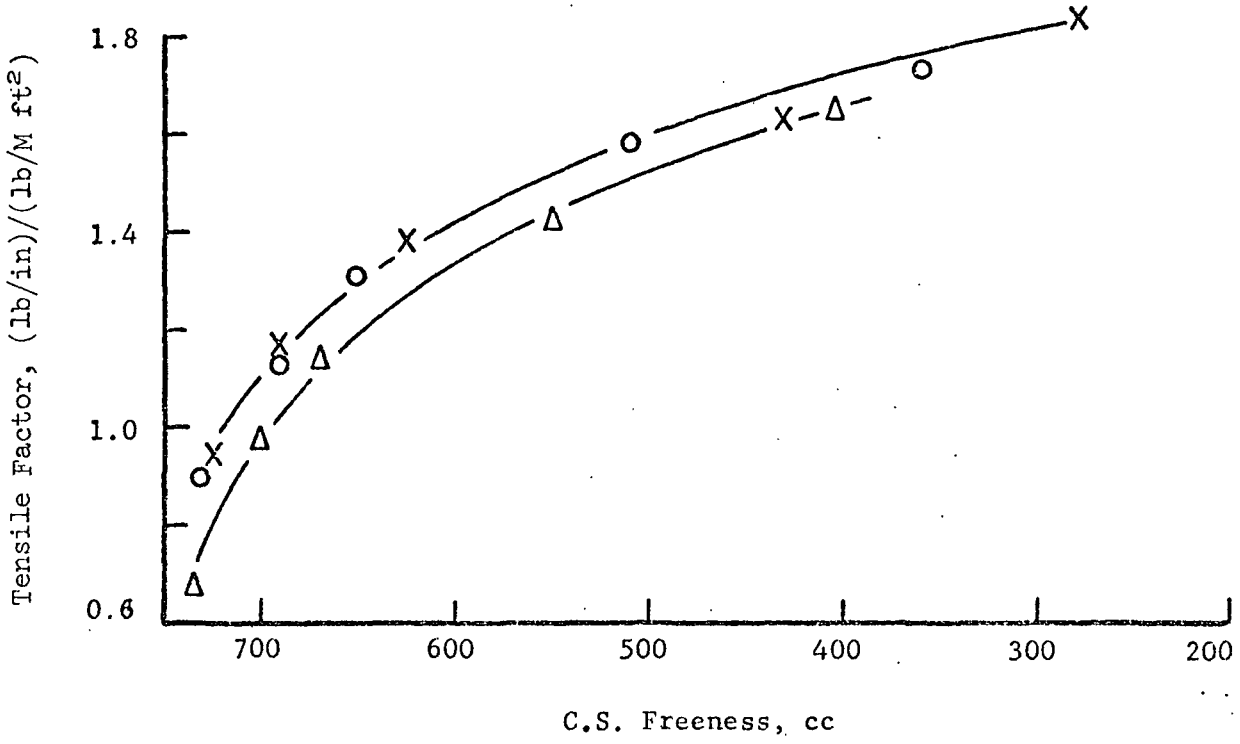


Figure 16. Effect of "Green" and "White" Liquor Treatments on Burst and Tensile Beating Curves.



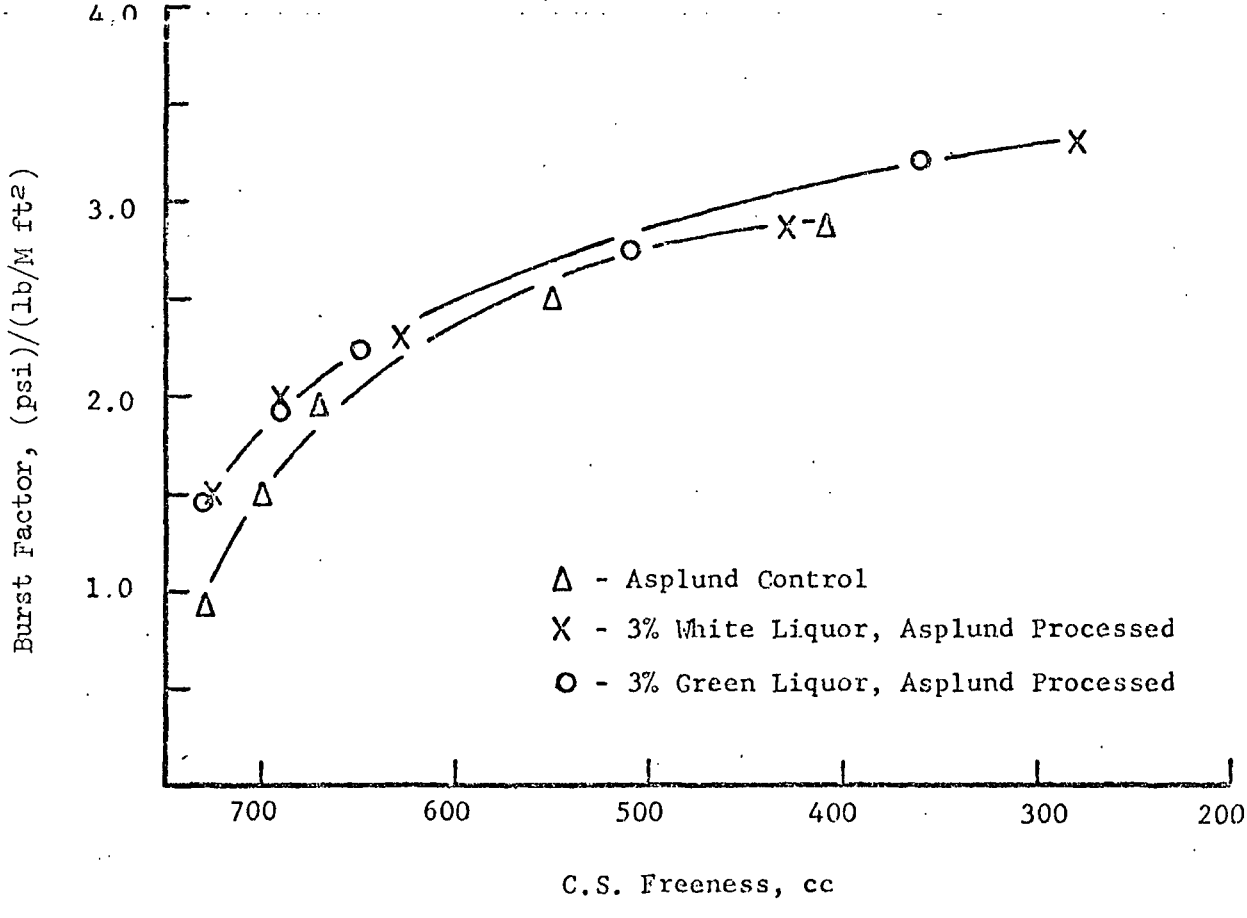


Figure 18. Effect of "Green" and "White" Liquor Treatments on Burst and Tensile vs. Freeness.

Table V compares the changes in sheet properties relative to the Asplund control at three freeness levels; namely, 600, 500, and 350 cc. For the treatment and process conditions employed, the "green" and "white" liquors generally produced relatively small changes in most properties. It is possible that longer Asplund dwell times and higher pressures would produce greater improvements.

If the "green" and "white" liquor treated stocks are compared to the untreated OCC at constant freeness, relatively large improvements in burst and decreases in ring compression strength are observed. However, these changes appear to result in large part from the differences in washing and hence, "fines" content between the Asplund control and the untreated OCC beater run evaluation.

Caustic, Sodium Carbonate, and Peroxide Treatments

For these trials, the following concentrations based on o.d. weight of fiber were applied in the Asplund mill.

Sodium Hydroxide: 3 and 5%

Sodium Carbonate: 8 and 13.25%

Hydrogen Peroxide: 2% in alkaline slurry

As mentioned previously, these trials were carried out using a dwell time of 5 minutes in the Asplund and a steam pressure of 100 psi. A control sample (Asplund control) was processed in the same manner as the chemically treated stocks.

The beater run results for the sodium hydroxide, sodium carbonate, and peroxide treatments are tabulated in Tables VI-VIII. The Asplund control results are identified as the 100 psi steam, 0% chemical trial in the tables. The

TABLE VI

Effect of Caustic Treatments in Asplund

Treatment Pressure psi	%NaOH	C.S. Freeness	Basis Weight lb/1000 ft^2	Caliper mils	Apparent Density lb/mil	Diff. %[d]	Burst Factor psi/lb	Diff. %[d]	Tensile Factor lb/in / lb	Diff. %[d]
				0 Minute Beating Time						
Atm.[a]	0	665	13.8	6.1	2.25	- 5.1	1.28	+45.4	0.89	+34.8
100[bc]	0	720	13.4	5.6	2.37	---	0.88	---	0.66	---
100[c]	3	690	13.4	5.3	2.51	+ 5.9	1.51	+71.6	0.91	+37.9
100[c]	5	700	14.0	5.3	2.62	+10.5	1.50	+70.4	0.91	+37.9
				5 Minute Beating Time						
Atm.[a]	0	605	13.6	5.8	2.36	- 1.2	1.66	+13.7	1.18	+22.9
100[bc]	0	680	13.1	5.5	2.39	---	1.46	---	0.96	---
100[c]	3	640	13.8	5.2	2.67	+11.7	2.04	+39.7	1.22	+37.0
100[c]	5	630	13.3	5.0	2.64	+10.5	2.02	+38.4	1.14	+18.8
				10 Minute Beating Time						
Atm.[a]	0	545	13.8	5.5	2.52	+ 2.4	1.94	+12.8	1.34	+19.6
100[bc]	0	650	13.4	5.5	2.46	---	1.72	---	1.12	---
100[c]	3	570	13.6	4.8	2.84	+15.4	2.46	+43.0	1.37	+22.3
100[c]	5	560	13.3	4.8	2.77	+12.6	2.35	+36.6	1.34	+19.6
				20 Minute Beating Time						
Atm.[a]	0	375	14.0	5.0	2.78	+ 3.3	2.62	+ 7.8	1.54	+11.6
100[bc]	0	505	13.8	5.1	2.69	---	2.43	---	1.38	---
100[c]	3	410	13.6	4.6	2.93	+ 8.9	2.80	+15.2	1.61	+16.7
100[c]	5	380	13.7	4.6	2.94	+ 9.3	2.97	+22.2	1.62	+17.4
				30 Minute Beating Time						
Atm.[a]	0	225	13.0	4.6	2.79	- 1.1	2.90	+ 1.4	1.76	+ 9.3
100[bc]	0	345	13.8	4.9	2.82	---	2.86	---	1.61	---
100[c]	3	215	14.0	4.5	3.10	+ 9.9	3.14	+ 9.8	1.78	+10.6
100[c]	5	220	13.4	4.4	3.02	+ 7.1	3.26	+14.0	1.87	+16.1

TABLE VII

Effect of Na_2CO_3 Treatments in Asplund

Treatment Pressure psi	Treatment % Na_2CO_3	C.S. Freeness	Basis Weight lb/1000 ft^2	Caliper mils	Apparent Density lb/mil	Apparent Density Diff. %[d]	Burst Factor psi/lb	Burst Factor Diff. %[d]	Tensile Factor lb/in / lb	Tensile Factor Diff. %[d]
				0 Minute Beating Time						
Atm.[a]	0	665	13.8	6.1	2.25	- 5.1	1.28	+45.4	0.89	+34.8
100[bc]	0	720	13.4	5.6	2.37	---	0.88	---	0.66	---
100[c]	8	715	14.0	5.4	2.61	+10.1	1.29	+46.5	0.80	+21.2
100[c]	13.25	720	13.9	5.5	2.54	+ 7.2	1.31	+48.9	0.83	+25.8
				5 Minute Beating Time						
Atm.[a]	0	605	13.6	5.8	2.36	- 1.2	1.66	+13.7	1.18	+22.9
100[bc]	0	680	13.1	5.5	2.39	---	1.46	---	0.96	---
100[c]	8	670	13.7	5.1	2.68	+12.1	1.76	+20.5	1.09	+13.5
100[c]	13.25	675	13.7	5.1	2.69	+12.6	1.82	+24.6	1.12	+16.7
				10 Minute Beating Time						
Atm.[a]	0	545	13.8	5.5	2.52	+ 2.4	1.94	+12.8	1.34	+19.6
100[bc]	0	650	13.4	5.5	2.46	---	1.72	---	1.12	---
100[c]	8	620	14.0	5.0	2.78	+13.0	2.18	+26.7	1.29	+15.2
100[c]	13.25	620	13.7	4.8	2.82	+14.6	2.24	+30.2	1.25	+11.6
				20 Minute Beating Time						
Atm.[a]	0	375	14.0	5.0	2.78	+ 3.3	2.62	+ 7.8	1.54	+11.6
100[bc]	0	505	13.8	5.1	2.69	---	2.43	---	1.38	---
100[c]	8	465	13.9	4.8	2.87	+ 6.7	2.70	+11.1	1.59	+15.2
100[c]	13.25	480	13.7	4.8	2.87	+ 6.7	2.62	+ 7.8	1.50	+ 8.7
				30 Minute Beating Time						
Atm.[a]	0	225	13.0	4.6	2.79	- 1.1	2.90	+ 1.4	1.76	+ 9.3
100[bc]	0	345	13.8	4.9	2.82	---	2.86	---	1.61	---
100[c]	8	280	13.7	4.5	3.04	+ 7.8	3.03	+ 5.9	1.76	+ 9.3
100[c]	13.25	315	13.3	4.6	2.92	+ 3.5	3.21	+12.2	1.67	+ 3.7

TABLE VIII

Effect of Peroxide Treatments in Asplund

Treatment Pressure psi	Treatment $\%H_2O_2$	C.S. Freeness	Basis Weight lb/1000 ft^2	Caliper mils	Apparent Density lb/mil	Apparent Density Diff. %[d]	Burst Factor psi/lb	Burst Factor Diff. %[d]	Tensile Factor lb/in / lb	Tensile Factor Diff. %[d]
				0 Minute Beating Time						
Atm.[a]	0	665	13.8	6.1	2.25	-5.1	1.28	+45.4	0.89	+34.8
100[bc]	0	720	13.4	5.6	2.37	---	0.88	---	0.66	---
100[c]	2	720	13.4	5.5	2.43	+2.5	1.09	+23.9	0.68	+ 3.0
				5 Minute Beating Time						
Atm.[a]	0	605	13.6	5.8	2.36	-1.2	1.66	+13.7	1.18	+22.9
100[bc]	0	680	13.1	5.5	2.39	---	1.46	---	0.96	---
100[c]	2	685	13.6	5.3	2.57	+7.5	1.59	+ 8.9	0.92	- 4.2
				10 Minute Beating Time						
Atm.[a]	0	545	13.8	5.5	2.52	+2.4	1.94	+12.8	1.34	+19.6
100[bc]	0	650	13.4	5.5	2.46	---	1.72	---	1.12	---
100[c]	2	640	13.4	5.0	2.67	+8.5	1.87	+ 8.7	1.14	+ 1.8
				20 Minute Beating Time						
Atm.[a]	0	375	14.0	5.0	2.78	+3.3	2.62	+ 7.8	1.54	+11.6
100[bc]	0	505	13.8	5.1	2.69	---	2.43	---	1.38	---
100[c]	2	490	13.4	4.8	2.79	+3.7	2.56	+ 5.3	1.44	+ 4.3
				30 Minute Beating Time						
Atm.[a]	0	225	13.0	4.6	2.79	-1.1	2.90	+ 1.4	1.76	+ 9.3
100[bc]	0	345	13.8	4.9	2.82	---	2.86	---	1.61	---
100[c]	2	315	13.6	4.7	2.91	+3.2	3.03	+ 5.9	1.76	+ 9.3

untreated OCC results from the March, 1979, status report are also shown in these tables and are identified as atmospheric pressure, 0% chemical trials. As discussed previously, this untreated OCC stock was merely dispersed and dewatered prior to beating whereas the Asplund stocks were washed after treatment.

The 5% sodium hydroxide and 13.25% sodium carbonate treatments produced about the same effects on sheet properties as the lower concentration levels. Therefore, the results obtained at the lower applications levels are discussed in detail below.

When plotted against freeness, the results in Figure 20 show that the sodium carbonate and hydroxide treatments improved bursting strength relative to the Asplund control. The amount of improvement was about the same for these two treatments. The hydrogen peroxide treatment had a lesser effect on burst than the carbonate or caustic treatments and the levels achieved were not markedly different from the Asplund control.

Figure 20 also indicates that the peroxide treatment tended to lower tensile strength relative to the Asplund control. In contrast, small improvements were generally obtained with the caustic and carbonate treatments at a given freeness.

When the ring compression results were plotted against freeness in Figure 21, the results on the treated stocks were generally lower than in the Asplund control except at very high freeness. There appeared to be little difference between the peroxide, carbonate, and caustic treatments in terms of ring compression strength.

Table IX compares the various sheet properties obtained with the various treatments at three freeness levels; namely, 600, 500, and 350 cc. At 600 cc freeness, the sodium hydroxide and carbonate treatments gave burst improvements

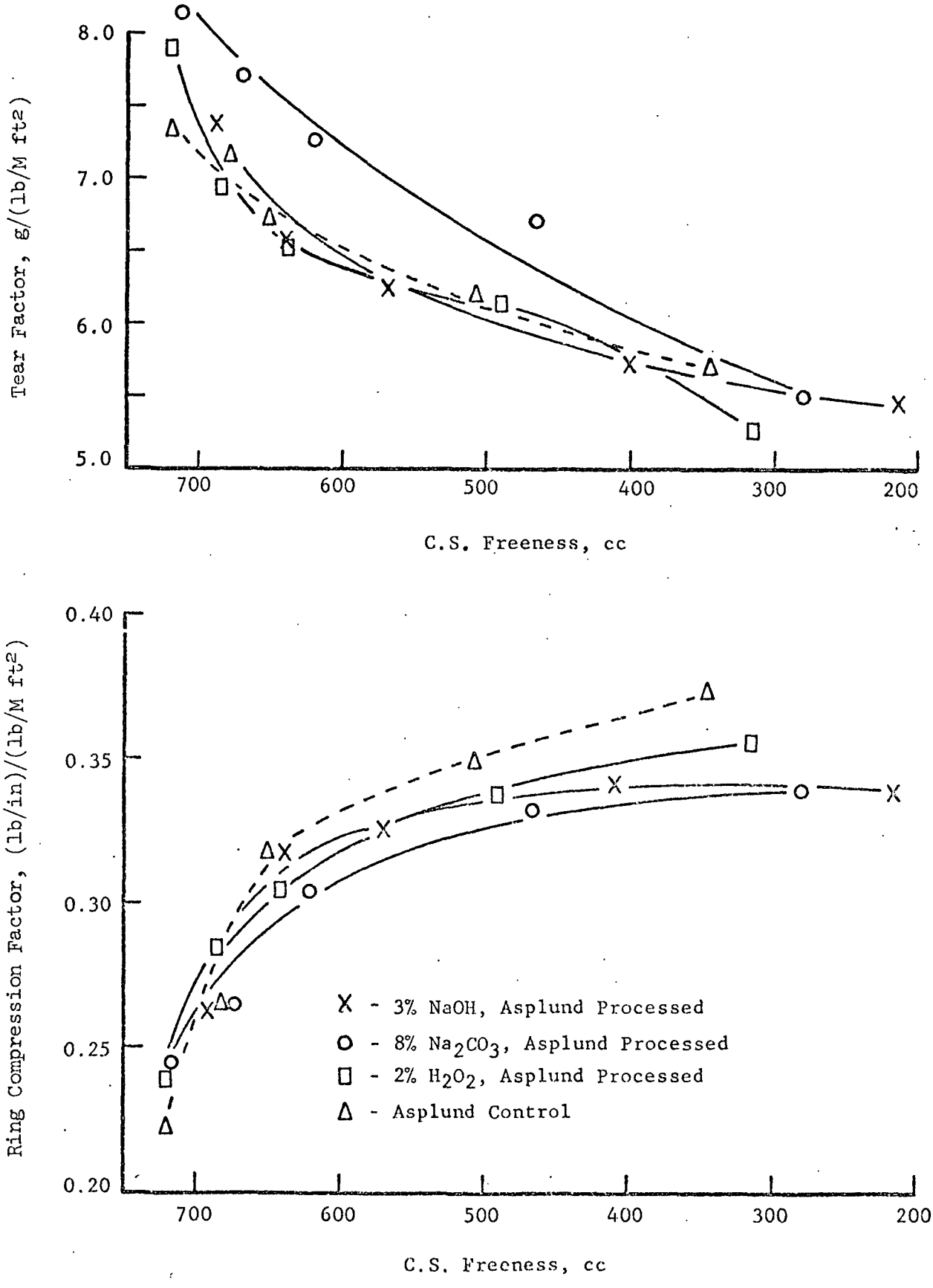


Figure 21. Ring Compression and Tearing Strength vs. Freeness for Various Chemical Treatments

TABLE IX Continued

	Untreated OCC	Asplund Control	Asplund Treatments: Sodium Carbonate 8% Na_2CO_3	% Diff.	13.25% Na_2CO_3	% Diff.
Properties at 600 ml CSF						
Sheet Density	2.37	2.54	2.79	+ 9.8	2.83	+11.4
Burst Factor	1.70	1.95	2.25	+15.4	2.30	+17.9
Mod. Ring Factor	0.335	0.327	0.307	- 6.1	0.321	- 1.8
Tensile Factor	1.20	1.22	1.32	+ 8.2	1.28	+ 4.9
Et Factor	148.0	140.0	150.0	+ 7.1	142.0	+ 1.4
Tear Factor	5.90	6.50	7.15	+10.0	6.35	- 2.3
Stretch, %	2.09	2.52	2.86	+13.5	2.62	+ 4.0
TEA, ft lb/ft^2	2.9	3.5	4.6	+31.4	4.0	+14.3
Properties at 500 ml CSF						
Sheet Density	2.50	2.69	2.85	+ 5.9	2.86	+ 6.3
Burst Factor	2.15	2.43	2.57	+ 5.8	2.57	+ 5.8
Mod. Ring Factor	0.381	0.349	0.326	- 6.6	0.336	- 3.7
Tensile Factor	1.39	1.39	1.52	+ 9.4	1.46	+ 5.0
Et Factor	155.0	150.0	158.0	+ 5.3	155.0	+ 3.3
Tear Factor	5.70	6.18	6.82	+10.4	6.14	+ 0.6
Stretch, %	2.24	2.72	2.94	+ 8.1	2.83	+ 4.0
TEA, ft lb/ft^2	3.8	4.4	5.4	+22.7	4.9	+11.4
Properties at 350 ml CSF						
Sheet Density	2.78	2.82	2.97	+ 5.3	2.91	+ 3.2
Burst Factor	2.65	2.85	2.90	+ 1.8	3.09	+ 8.4
Mod. Ring Factor	0.397	0.372	0.337	- 9.4	0.335	- 9.9
Tensile Factor	1.58	1.60	1.69	+ 5.6	1.64	+ 2.5
Et Factor	167.0	167.0	172.0	+ 3.0	171.0	+ 2.4
Tear Factor	5.27	5.69	5.94	+ 4.4	5.50	- 3.3
Stretch, %	2.52	2.79	2.94	+ 5.4	2.82	+ 1.1
TEA, ft lb/ft^2	4.6	5.1	5.8	+13.7	5.3	+ 3.9

Note: Differences are based on Asplund control as reference.

All factors obtained by dividing the test average by the basis weight in lb/M ft2

FUTURE WORK

Several areas of future work are planned or are in progress. They are as follows:

1. Low consistency ozonation studies.
2. Evaluation of effects of pre- and post-refining upon ozonated OCC. Pre-refining studies are already in progress.
3. Evaluation of strength characteristics and economics of ozonated OCC/virgin pulp blends.
4. Process and pilot development.
5. Chemical treatments: complete work on chemical agents discussed herein to better define the effects of yield loss and chemical treatment.

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(c) Project the glassware results on hand all the way to an apparent successful commercial prototype in order to establish the overall economic feasibility of commercialization of the proposed method.

The above results and discussions will, to a great extent, determine our future actions; but, assuming all signs are "go," we propose then to follow with these steps -

1. Meet with all the representatives of the sponsoring group and outline our action program.

2. Eventually get a commitment from the group as to how they propose to share the expenses of the program through satisfactory operation of the first commercial prototype.

3. The prime sponsor would be determined and the site and practical size of the prototype established. This would determine the source of raw material used in further pilot plant ozonation and paper machine runs. The prime sponsor would establish the conditions and results required in the pilot plant and paper machine run programs on which he would be willing to proceed to the commercial prototype.

4. With this commitment made, pilot trials would be contracted for and the pulp prepared for the paper machine trials. Enough pulp would be made to both conduct laboratory tests on the finished product, as well as enough to make enough boxes for further physical testing.

5. The commercial prototype would be designed and a final commitment made by the prime sponsor as to its purchase, installation, and operation.

Bill, we are not trying to overwhelm you with the scope of such a joint venture, but it is best we establish the basis of practical cooperation. Impco, as you understand, must prepare marketing parameters in order that we can determine and justify Impco expenditures in manpower and a development budget for the project. We must, at the beginning, see the "end of the tunnel" even though we know that down the line there will be possible changes in direction or even objectives.

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For your information and for transmittal to the sponsors, the following may be of interest. Impco has capabilities in gas phase technology as follows:

1. Proven gas phase treatment equipment which has operated at 500 tons per day using either chlorine or chlorine dioxide in the gas phase on 30 to 40% consistency pulp. Ozone simulation at approximately 375 tons per day has been done in this same equipment.

2. Impco's oxygen bleaching equipment is in daily operation at 500 tons per day with several similar installations operating worldwide with one at 1200 ton per day rate.

3. Results from numerous pilot trials on a variety of pulps for a variety of different effects indicate excellent simulation of laboratory results.

4. A team of experienced operators of both pilot and commercial installations of gas phase equipment.

5. A design team capable of machinery as well as system design up through construction drawings.

6. Technicians familiar with ozone technology proficient to work with your group in getting the type of simulation capable of being converted to commercial application.

7. Sources of information to obtain design and estimates of the ozone manufacturing and oxygen reclaim system so economically necessary to the success of any ozone program.

Impco is ready to proceed with the three introductory steps at your earliest convenience. We must say, however, that many of us are committed the last two weeks of September and the first week of October.

In any case, we most anxiously await your comments concerning our proposals.

With best regards.

Very truly yours,

J. K. Perkins
Manager Market Development

JKP:mbl